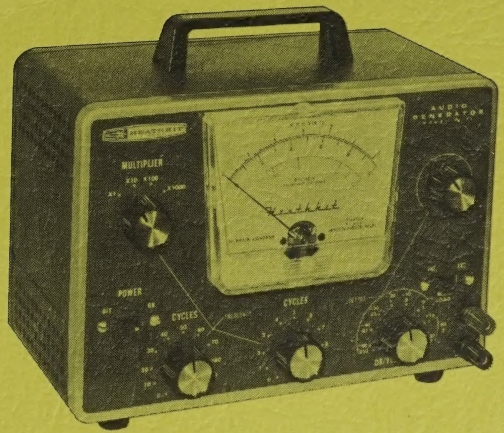
HEATHKIT®



THE HEATH
AUDIO
GENERATOR

MODEL IGW-72

OWNER'S MANUAL

THE HEATH AUDIO GENERATOR

MODEL IGW-72

Your new IGW-72 Audio Generator, with its wide range of accurate output frequencies, is an ideal audio-lab or service instrument for high-fidelity audio equipment. With this instrument, the user can easily switch-select the desired audio frequency. The output level is monitored on the large panel meter.

CONTENTS

HEATHKIT

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INTRODUCTION

The Heath Model IGW-72 Audio Generator, which is designed for laboratory use, provides nearly perfect sine wave signals with metered output level. This Audio Generator can be used as a signal source for bridges, for harmonic distortion measurements, as an external modulator for an RF signal generator, and in testing audio amplifiers for gain and frequency response.

Accurate, repeatable frequency selection is accomplished by the use of three switches. These switches select the first two significant figures and multiplier of frequencies between 10 cps and 100 kc.

The Generator can provide output signals into a high impedance load (10,000 Ω and higher) with full scale ranges of .003 to 10 volts. Many uses require a signal source with 600 Ω (industry standard) impedance. Such signals are available from the Generator with full scale ranges of .003 to 1 volt.

OPERATION

OUTPUT TERMINATION

The output of the Audio Generator must be properly terminated to obtain accurate meter indications.

To obtain correct meter readings with a high impedance load (10 KΩ or more): Set the 600 Ω LOAD switch to INTernal, and set the DB/VOLTS switch to the nearest full scale (F.S.) value above the desired output level. Then adjust the OUTPUT control to give the desired output as indicated on the proper meter scale.

EXAMPLE: For an output voltage of 7.3 volts, set the DB/VOLTS switch to 10 volts. Then turn the OUTPUT control to give a 7.3 reading on the 0-10 scale of the meter.

EXAMPLE: For an output of .025 volts, set the DB/VOLTS switch to .03 volts. Then turn the OUTPUT control to give a 2.5 reading on the 0-3 meter scale.

To obtain correct meter readings with an external 600 Ω load (1 volt maximum output signal level): set the LOAD switch to EXTernal and proceed as before.

FREQUENCY SELECTION

To select the desired frequency, set the Generator controls as follows:

0-100 CYCLES switch - to the first significant figure.

0-10 CYCLES switch - to the second significant figure.

MULTIPLIER switch - to the desired position.

EXAMPLE: For a frequency of 35 cps, set the 0-100 CYCLES switch to 30, the 0-10 CYCLES switch to 5, and the MULTIPLIER switch to X1.

EXAMPLE: For a frequency of 72 kc, set the 0-100 CYCLES switch to 70, the 0-10 CYCLES switch to 2, and the MULTIPLIER switch to X1000.

DB/VOLTS SWITCH AND OUTPUT CONTROL

To select the desired output amplitude into a high impedance load (10 KΩ or higher), set the Generator controls as follows:

LOAD switch - to INTernal.

DB/VOLTS switch - to the nearest full scale value above the desired output.

OUTPUT control - to give the desired output as indicated on the appropriate meter scale.

EXAMPLE: For a desired voltage of 5.5 volts, set the DB/VOLTS switch to 10. Then adjust the OUTPUT control for a 5.5 reading on the 0-10 voltmeter scale.

To select the desired output amplitude into an external 600 Ω load (.003 to 1 volt positions), set the LOAD switch to EXTernal and proceed as before.

USING THE DB SCALE

The decibel is a ratio between two power or voltage levels. It may be applied to voltage levels if the impedances are identical. It may be used as an indication of quantity for one power or voltage level, if the other level is defined. In this instrument, the db scale is based on a reference, or standard level, of 0 db = 1 milliwatt in 600 Ω. If used with a 600 Ω external load, the meter reading is expressed in dbm (decibels with reference to a power of one milliwatt in a 600 Ω load) and the reference level is automatically defined.

If the instrument is used with loads other than 600 Ω (but substantially less than 10 KΩ), correction factors may be calculated for the voltage reduction in the attenuator and for the db level.

If the instrument is used with high impedance loads, the relation between two signal levels may be expressed as a number of db difference.

For example, if a device requires a signal of .61 volt on one input jack and a signal of .012 volt on another input jack to produce the same output level, how many db difference is there between the signals at the two input jacks?

The .61 volt signal indicates -2 db on the meter and 0 db on the output switch. = -2.

The .012 volt signal indicates -6 db on the meter and -30 db on the output switch. = -36.

The total difference between the signals is (-2) - (-36) = 34 db.

NOTE: Theoretically the input impedances should be equal in the above example. The method described is generally more useful than calculating the power level at each input using voltage and input impedance and the following formula:

$$db = 10 \log \frac{P1}{P2} = 10 \log \frac{E1^2/R1}{E2^2/R2}$$

for equal impedances this reduces to:

$$db = 10 \log \left(\frac{E1}{E2}\right)^2 = 20 \log \frac{E1}{E2}$$

Although theorectically correct, an erroneous impression may be gained by using the latter approach; for instance changing a 10 KΩ grid resistor to 10 megohms decreases the power level by a factor of 1000, or 30 db, yet the input voltage may remain unchanged.

CALIBRATION

Calibration and adjustment of the Audio Generator have been completed at the factory. After extensive use, or if a tube or circuit component is replaced, the Generator may be recalibrated using the following procedure.

METER CALIBRATION WITH AN AC VOLTMETER

NOTE: The AC voltmeter should have a sensitivity of at least 500 Ω per volt on the 10 volt scale.

Set the Generator controls as follows:

MULTIPLIER switch - X1.
0-100 CYCLES switch - 100.
0-10 CYCLES switch - 0.
OUTPUT control - fully clockwise.
DB/VOLTS switch - fully clockwise (10).

( ) Connect the AC voltmeter to the Generator Output binding posts.

( ) Locate the Meter control on top of the Generator chassis. See Figure 1 on Page 5. Adjust this control so the AC voltmeter and the Generator meter read the same.

( ) Disconnect the AC voltmeter from the Generator.

METER CALIBRATION WITHOUT AN AC VOLTMETER

Set the Generator controls to the following positions:

MULTIPLIER - X1.
Both CYCLES switches - 0.
OUTPUT control - fully clockwise.
DB/VOLTS switch - fully clockwise (10).

CAUTION: Do not turn the OUTPUT control during the following adjustments. If it is not in the fully clockwise position, it may be damaged as the following adjustments are performed.

( ) Connect a 9" length of insulated wire between the red (top) output binding post and lug 2 (brown wire) of the pilot lamp socket on terminal board B. See Figure 1.

( ) Adjust the Meter control (on top of the Generator chassis) to obtain a reading of 6.3 on the 0 to 10 scale of the meter. Then remove the wire.

OSCILLATOR ADJUSTMENT

Be sure all leads have been disconnected from the Output binding posts of the Generator. Then set the Generator controls as follows:

MULTIPLIER - X1.
0-100 CYCLES - 10.
0-10 CYCLES - 0.
OUTPUT control - fully clockwise.
DB/VOLTS switch - fully clockwise.

( ) Adjust the Oscillator control (on top of the chassis) for a slightly higher than full scale (10 on the 0-10 scale) meter reading.

( ) Move the MULTIPLIER switch through the X10, X100, and X1000 positions. The meter should not indicate less than full scale on any of these ranges. If the meter indicates less than full scale, readjust the Oscillator control for full scale (10 volts) meter reading. With the Oscillator control properly adjusted, the meter should indicate no less than full scale on each setting of the MULTIPLIER switch. A higher than normal output level on any range will cause distortion in the Generator output signal.

This completes the calibration and adjustment of the Generator.

IN CASE OF DIFFICULTY

1. If the 3 watt candelabra lamp (at bottom of chassis) does not glow, be sure it is tight in its socket.

2. Check the tubes with a tube tester or by substitution. Refer to Figure 1 for the tube locations.

3. If, after careful checks, the trouble is still not located and a voltmeter is available, check voltage readings against those shown on the Schematic. NOTE: All voltage readings were taken with an 11 megohm input vacuum tube voltmeter. Voltages may vary as much as 10%.

4. A review of the circuit Description will prove helpful in indicating where to look for the source of the trouble.

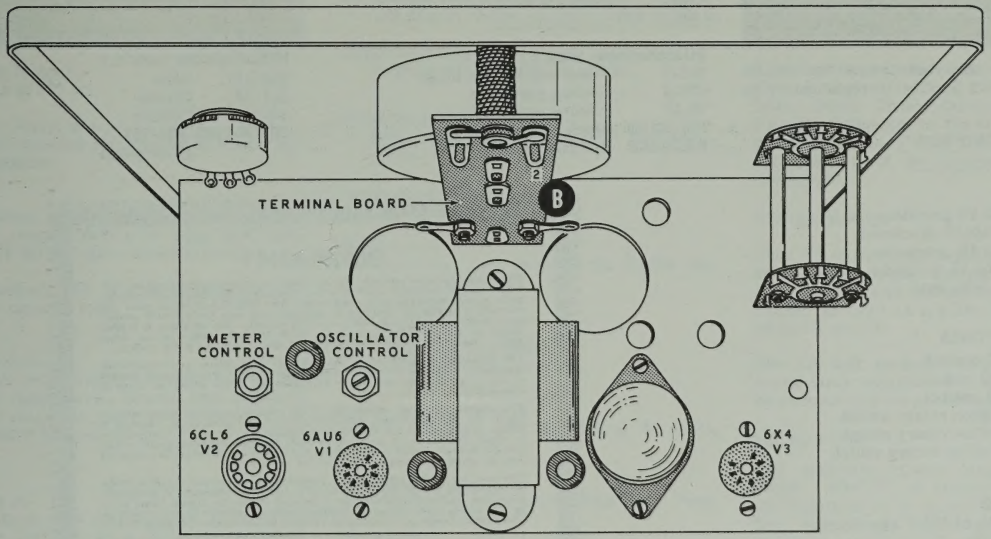

TERMINAL BOARD
B
2
METER CONTROL
OSCILLATOR CONTROL
6CL6 V2
6AU6 V1
6X4 V3

Figure 1

REPLACEMENT PARTS

This list covers only those items that may be difficult to obtain locally if replacement is required.

PART No.	DESCRIPTION
RESISTORS	
2-97	25 KΩ 1% precision
2-98	33.3 KΩ 1% precision
2-99	50 KΩ 1% precision
2-11	100 KΩ 1% precision
3T-2	5000 Ω 20 watt
CONTROLS-SWITCHES	
10-34	600 Ω control
10-7	5000 Ω control
10-8	10 KΩ control
63-8	4-position rotary switch
63-107	8-position rotary switch
63-108	11-position rotary switch
MISCELLANEOUS	
25-37	40-40 μfd 450 V electrolytic capacitor
46-3	Filter choke
54-57	Power transformer
56-26	Crystal diode (1N191)
407-85	Meter
Miscellaneous (cont'd.)	
412-2	3-watt candelabra lamp
427-3	Binding post base
75-17	Binding post insulator
100-M16B	Black binding post cap
100-M16R	Red binding post cap
Miscellaneous (cont'd.)	
462-187	Knob
211-15	Handle
90-235	Cabinet
203-80F755-756-757	Front panel

WARRANTY

The Heath Company warrants that its factory-wired products (except any batteries supplied therewith) shall be free of defects in materials and workmanship under normal conditions of use and service. The obligation of Heath under this warranty is limited to repairing or replacing any such factory-wired product upon verification that it is defective in this manner. This obligation is further limited to such defective products for which Heath is notified of the defect within a period of one year from the original date of shipment of the product.

The obligation of Heath under this warranty with respect to transportation expenses is limited to the cost of shipping the repaired or replacement product to the buyer, provided such repair or replacement comes within the terms of this warranty.

The foregoing warranty extends only to the original buyer and is expressly in lieu of all other warranties, expressed or implied. The foregoing warranty is further in lieu of all other obligations or liabilities on the part of Heath and in no event shall the Heath Company be liable for any anticipated profits, consequential damages, loss of time or other losses incurred by the buyer in connection with the purchase, operation or use of the product.

This warranty applies only to Heath products sold and shipped to points within the continental United States and to APO and FPO shipments. Warranty replacements for Heath products sold or shipped outside the United States is on an f.o.b. factory basis. Contact the Heath authorized distributor in your country or write: Heath Company, International Division, Benton Harbor, Michigan, U.S.A.

HEATH COMPANY

SPECIFICATIONS

Frequency Range -
10 cps to 100 kc.

Frequency Selection -
Switch selected, two significant figures and a multiplier.

Output Voltage -
Eight ranges, .003 to 10 volts (full scale) with 10 KΩ or higher external load.

Six ranges, .003 to 1 volt (full scale) with 600 Ω external load.

Output Impedance -
10 volt range, varies between 0 and 1000 Ω.
3 volt range, varies between 800 and 1000 Ω.
1 volt range and lower, 600 Ω External load and 290 Ω Internal load.

db Ranges -
-62 db to +22 db; -12 db to +2 db on the meter, and -50 db to +20 db on the Output switch in 10 db steps.

dbm Ranges (600 Ω External Load) -
-62 dbm to +2 dbm; 0 dbm = 1 mw in 600 Ω.

Output Indication -
Voltage and db scales on meter.

Output Meter Accuracy -
±5% of full scale with proper load termination.

Frequency Accuracy -
Within 5%.

Distortion -
Less than .1% from 20 to 20,000 cps.

Tube Complement -
6X4 rectifier.
6AU6 voltage amplifier.
6CL6 cathode follower.

Power Requirements -
105-125 volts AC, 50/60 cps, 40 watts.

Dimensions -
9-1/2" wide x 6-1/2" high x 5" deep.

Net Weight -
6 lbs.

CIRCUIT DESCRIPTION

The circuitry of the Audio Generator can be divided into four sections: Power Supply, Oscillator, Output Circuit (attenuator), and Meter Circuit. Referring to the Schematic Diagram while reading the Circuit Description may make the operation of the instrument more easily understood.

POWER SUPPLY

Tube V3 operates as a full-wave rectifier and its DC output voltage is well filtered by capacitors C6A and C6B and the filter choke. This DC voltage is used as a plate supply voltage for tubes V1 and V2.

The 6.3 volt secondary winding of the power transformer supplies filament voltage for all three tubes and the pilot lamp.

OSCILLATOR

The oscillator circuit consists of two tube stages: tube V1 is connected as a pentode and functions as a broad-band voltage amplifier; tube V2 is connected as a triode and serves as a cathode follower. Oscillation occurs in this circuit by introducing positive (regenerative) feedback from the cathode of tube V2 through the tungsten filament of the candelabra lamp to the cathode of tube V1.

A large negative (degenerative) feedback voltage is coupled from the cathode of tube V2 through what is called a "notch" filter circuit to the grid of tube V1. This negative feedback keeps tube V1 from oscillating at all but the notch frequency. At this one frequency, the negative feedback is at a minimum and phase shift is zero. See Figure 2.

Any tendency on the part of the oscillator circuit to produce signals of varying amplitude, is effectively controlled as follows: As the output signal of tube V1 increases, more current is drawn through the voltage divider consisting of the 3-watt lamp and Oscillator control R20. This increased current through the lamp increases the lamp temperature, and thus the lamp resistance increases also. The increased lamp resistance decreases the amount of positive feedback that is coupled to the cathode of tube V1. This decrease in positive feedback reduces the output signal level of tube V1.

When the oscillator output signal decreases, the lamp cools slightly. This causes the resistance of the lamp to decrease. The lower resistance of the lamp allows more positive feedback to be applied to the cathode of tube V1, thus increasing the output signal of tube V1. In this way, the lamp holds the output of the oscillator constant.

The output of tube V1 is determined by the setting of Oscillator control R20, which is set for a nominal 10 volt output level.

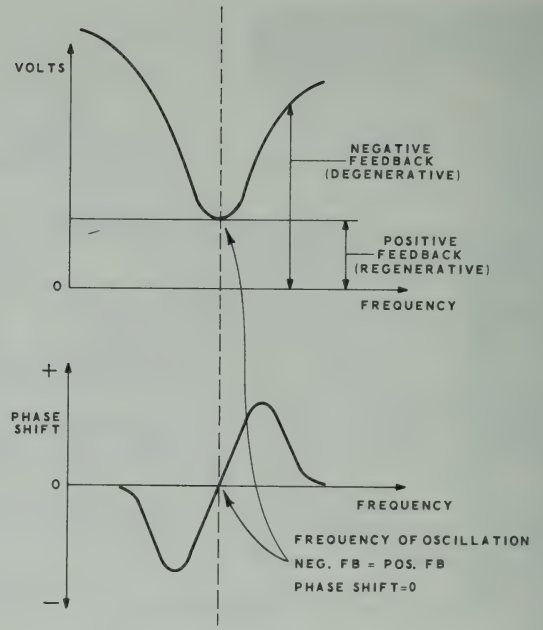


Figure 2

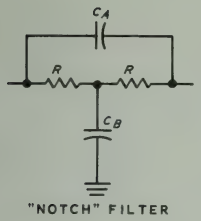


Figure 3

The notch frequency (oscillator frequency) is determined by the values of resistance and capacitance in the notch filter circuit. These components consist of resistors R1 through R16 on the Cycles switches, and capacitors C1 through C5 on the Multiplier switch (shown in the complete notch filter circuit).

Figure 3 shows the notch filter which consists of two resistors and two capacitors, in simplified form. The values of R, C_A, and C_B are shown in Figure 4 for any given switch setting.

VALUES OF C

MULTIPLIER	C_A	C_B
X1	.05	.5
X10	.005	.05
X100	500	.005
X1000	47	500

VALUES OF R

CYCLES	R	CYCLES	R
10	100 K	1	1 MEG
20	50 K	2	510 K
30	33.3 K	3	330 K
40	25 K	4	240 K
50	20 K	5	194 K
60	16.7 K	6	163 K
70	14.3 K	7	139 K
80	12.5 K	8	122 K
90	11.1 K	9	109 K
100	10 K	10	100 K

Figure 4

The following formula can be used to determine at what frequency the notch will occur for a particular set of resistors and capacitors. In this notch filter, C_B is 10 times larger than C_A, and both values of R are the same.

$$\text{Frequency} = \frac{1}{2\pi RC}$$

where $C = \sqrt{C_A C_B}$

and R = R1 = R2

(R may be only one resistor or several resistors in parallel.)

With the Multiplier switch in the X1 position and the 0-100 Cycles switch in the 10 position, the notch filter circuit is formed by capacitors C1 and C2 with resistors R3 and R8. Then the oscillator frequency is 10 cps. To produce a 20 cps signal, these resistances must be halved from 100 KΩ to 50 KΩ, since the frequency and resistance are inversely proportional. To increase the frequency to 100 cps (by a factor of 10), the capacitor values are decreased by a factor of 10. At the highest frequencies, the values of the capacitors are slightly below the theoretical value to allow for wiring capacitance.

Frequency variations within a 10 cps span are produced by the 0-10 Cycles switch. Here, the same circuit arrangement is used as in the 0-100 Cycles switch, however the resistance values are 10 times higher. These resistance values are connected in parallel with the resistors on the 0-100 Cycles switch to produce the 1 cps steps.

OUTPUT CIRCUIT

The output circuit consists of Output control R23, the DB/Volts switch, the 600 Ω Load switch, and resistors R29 through R42. When control R23 is set for maximum output, there is a signal of 10 volts applied across the voltage divider network consisting of resistors R29 through R41. When the DB/Volts switch is in the +20/10 position, the full output signal is present at the Output terminals. For each decreasing position of the DB/Volts switch, the signal available at the Output terminals is decreased by 10 db.

The output of the Audio Generator is designed to be fed into an external 600 Ω load on the .003 through 1 volt positions, and into a high impedance external load on the 3 and 10 volt positions. For use with high impedance external loads, the 600 Ω positions of the DB/Volts switch may be terminated in an internal load by placing the Load switch in the Internal position. This places resistor R42 across the output terminals. The internal load is automatically switched out of the circuit in the two HI Z positions of the DB/Volts switch. Figure 5 shows schematically the attenuation and load switching of the DB/Volts switch. The resistors in use at the various settings of the switch are easily identified.

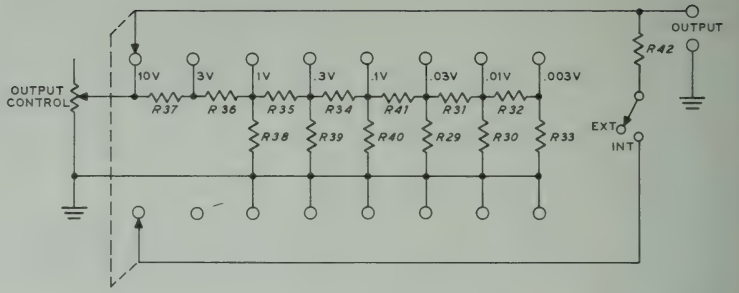
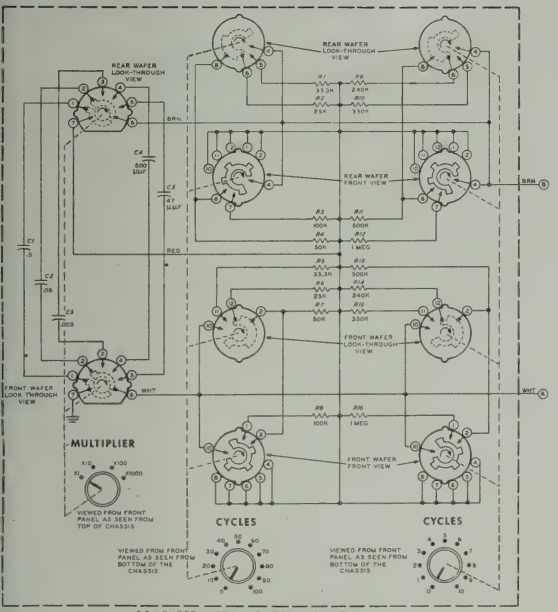


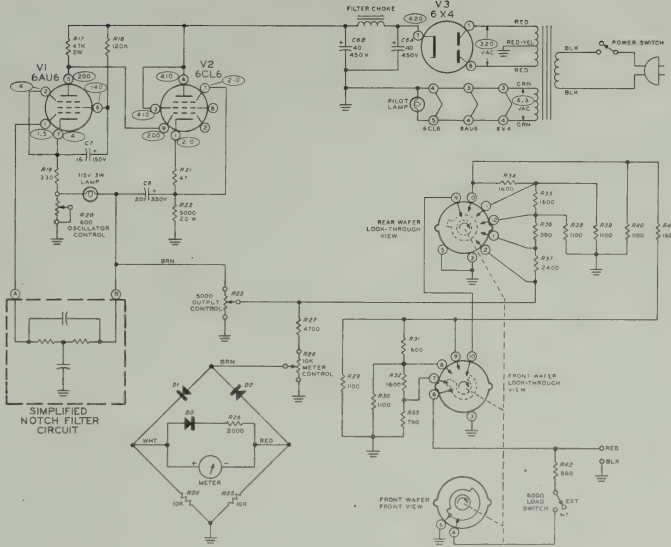
Figure 5

METER CIRCUIT

The meter circuit measures the voltage at the arm of Output control R23. A portion of this voltage is rectified by the bridge circuit consisting of diodes D1 and D2, and resistors R24 and R25. A third diode, D3, and resistor R26 are added to compensate for diode nonlinearity at low signal levels. Meter control R28 is adjusted to give the correct meter indication for the voltage present at the Output terminals.



COMPLETE NOTCH FILTER CIRCUIT



NOTES:
ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE.
ALL RESISTOR VALUES ARE IN OHMS (K = 1000, MEG = 1,000,000).
ALL CAPACITOR VALUES ARE IN μF UNLESS MARKED OTHERWISE.
(200) INDICATES VOLTAGE READING.
ALL VOLTAGES ARE DC POSITIVE UNLESS MARKED OTHERWISE.
ALL VOLTAGES ARE MEASURED FROM POINT INDICATED TO CHASSIS GROUND, EXCEPT AC VOLTAGES ON POWER TRANSFORMER WINDINGS.
VOLTAGE READINGS TAKEN WITH AN 11 MEGOHM INPUT VTVM.
VOLTAGES MAY VARY ±10%.

SCHEMATIC OF THE HEATHKIT® AUDIO GENERATOR MODEL IGW-72

HEATH COMPANY

BENTON HARBOR, MICHIGAN

595-751

Smead®
UPC 10332
No. 153L-2
HASTINGS, MN